COPY FOR MR. J. ALLAN ROSS

HYDRO-ELECTRIC INQUIRY COMMISSION

ENGINEERING DATA

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

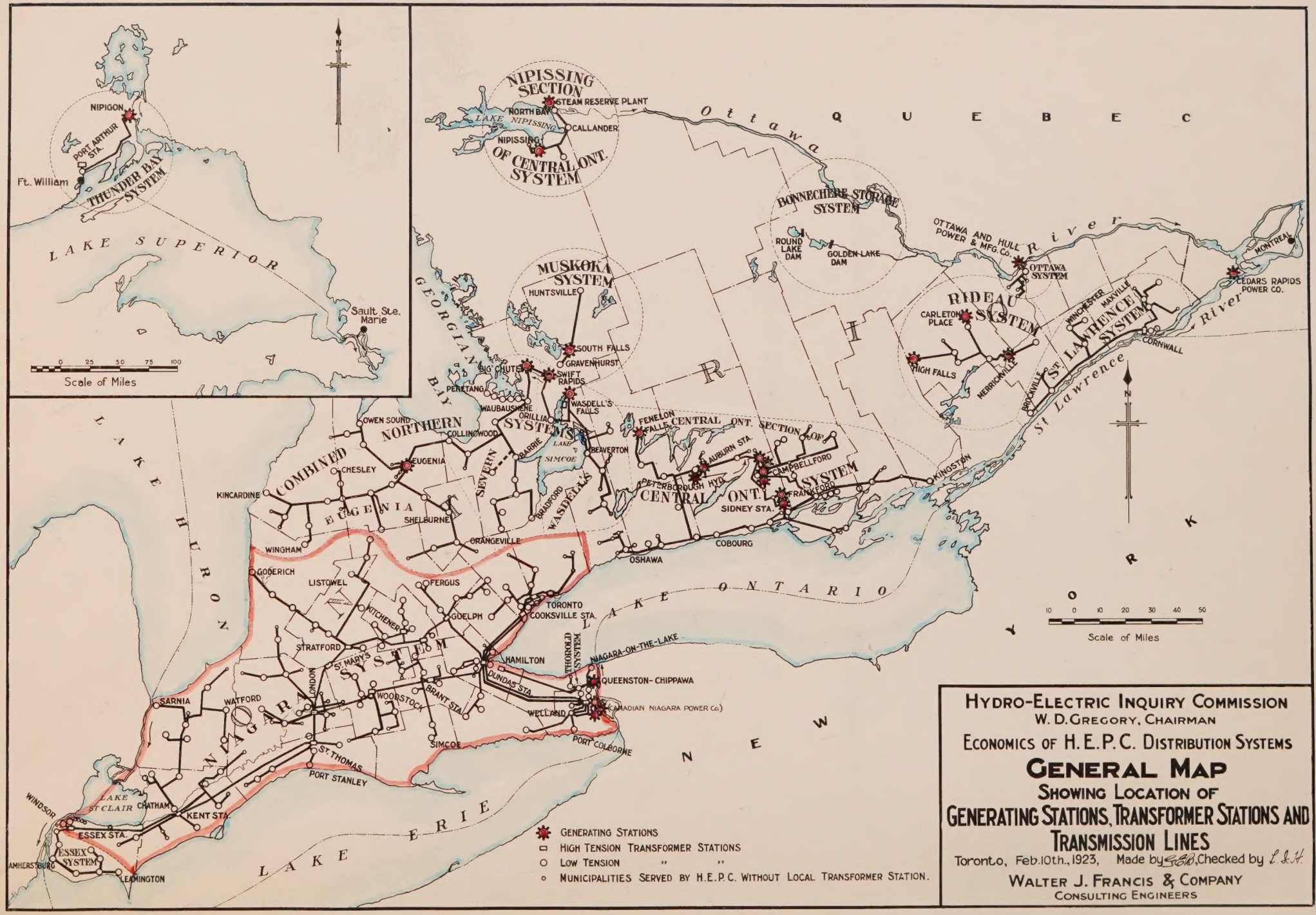
STUDY OF NIAGARA SYSTEM

PART II

BEING FOR PERIOD COMMENCING NOVEMBER 1st, 1921

WALTER J. FRANCIS & COMPANY

CONSULTING ENGINEERS


HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
GENERAL MAP
SHOWING LOCATION OF
GENERATING STATIONS, TRANSFORMER STATIONS AND TRANSMISSION LINES
Toronto, Feb. 10th., 1923, Made by G.S.B. Checked by L.S.H.
WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS
GENERATING STATIONS
HIGH TENSION TRANSFORMER STATIONS
LOW TENSION " "
MUNICIPALITIES SERVED BY H.E.P.C. WITHOUT LOCAL TRANSFORMER STATION.
Scale of Miles
NIPISSING SECTION OF CENTRAL ONT. SYSTEM
STEAM RESERVE PLANT
NORTH BAY
CALLANDER
LAKE NIPISSING
NIPISSING
MUSKOKA SYSTEM
HUNTSVILLE
SOUTH FALLS
GRAVENHURST
BIG CHUTE
SWIFT RAPIDS
WASDELL'S FALLS
PENETANG
WAUBAUSHENE
ORILLIA
BEAVERTON
LAKE SIMCOE
BONNECHERE STORAGE SYSTEM
ROUND LAKE DAM
GOLDEN LAKE DAM
OTTAWA AND HULL POWER & MFG. CO.
OTTAWA SYSTEM
RIDEAU SYSTEM
CARLETON PLACE
HIGH FALLS
MERRICKVILLE
BROCKVILLE
ST. LAWRENCE SYSTEM
WINCHESTER
MAXVILLE
CORNWALL
CEDARS RAPIDS POWER CO.
MONTREAL
Ottawa River
St Lawrence River
QUEBEC
NEW YORK
LAKE ONTARIO
LAKE ERIE
LAKE HURON
LAKE SUPERIOR
GEORGIAN BAY
NIPIGON
PORT ARTHUR STA.
Ft. William
THUNDER BAY SYSTEM
Sault Ste. Marie
Scale of Miles
OWEN SOUND
COLLINGWOOD
NORTHERN SYSTEMS
COMBINED EUGENIA
CHESLEY
EUGENIA
KINCARDINE
SHELBURNE
WINGHAM
GODERICH
LISTOWEL
SEVERN
BARRIE
BRADFORD
WASDELL'S
ORANGEVILLE
FERGUS
KITCHENER
GUELPH
STRATFORD
ST. MARYS
LONDON
WOODSTOCK
BRANT STA.
SIMCOE
SARNIA
WATFORD
NIAGARA SYSTEM
ST. THOMAS
PORT STANLEY
WINDSOR
LAKE ST CLAIR
CHATHAM
KENT STA.
ESSEX STA.
ESSEX SYSTEM
AMHERSTBURG
LEAMINGTON
FENELON FALLS
CENTRAL ONT. SECTION OF
AUBURN STA.
PETERBOROUGH HYD.
CENTRAL ONT. SYSTEM
CAMPBELLFORD
FRANKFORD
SIDNEY STA.
KINGSTON
COBOURG
OSHAWA
TORONTO
COOKSVILLE STA.
THOROLD SYSTEM
HAMILTON
DUNDAS STA.
NIAGARA-ON-THE-LAKE
QUEENSTON-CHIPPAWA
(CANADIAN NIAGARA POWER Co.)
WELLAND
PORT COLBORNE

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

To face frontispiece.

General Map Showing Location of

Generating Stations, Transformer Stations and Transmission Lines

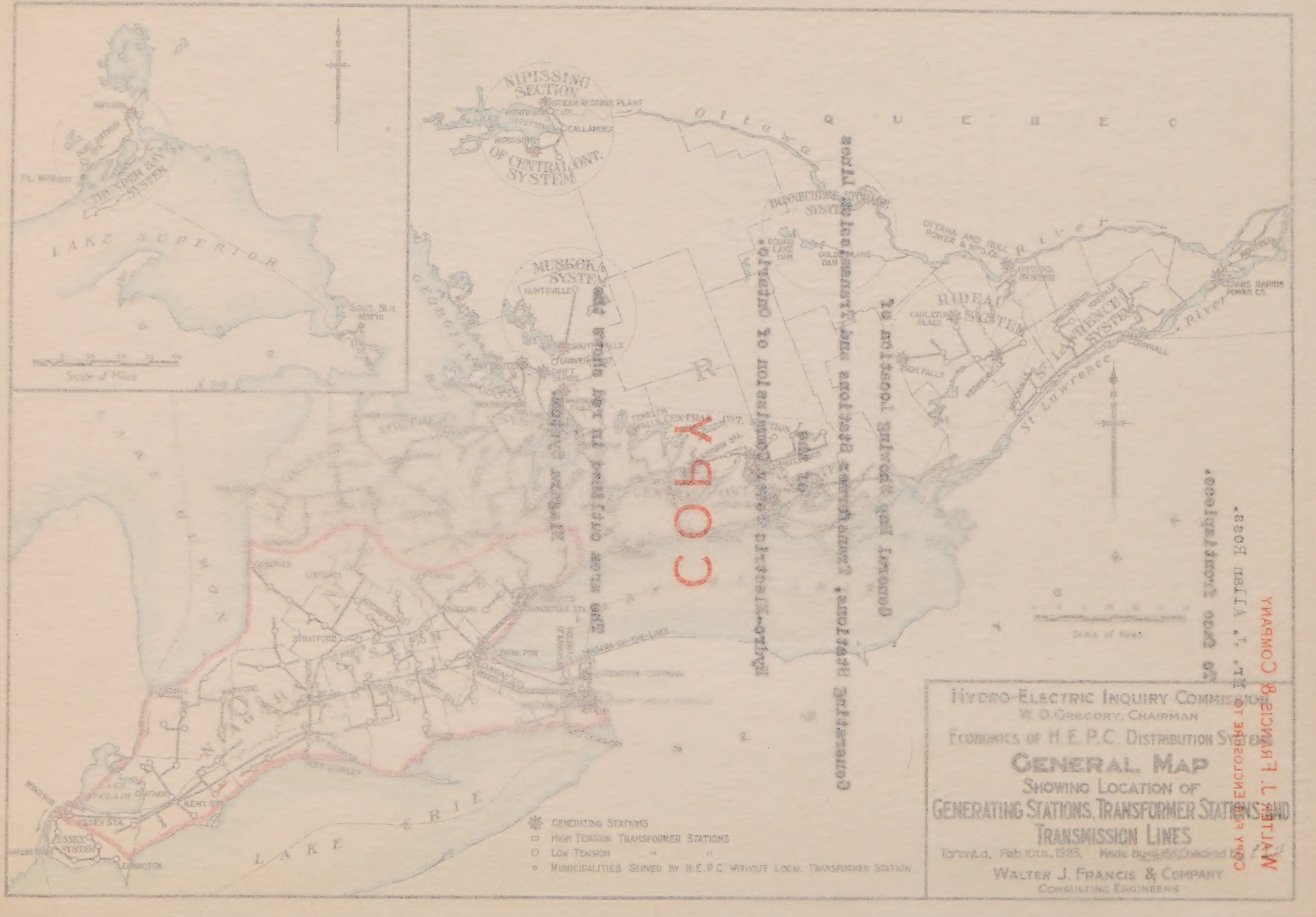
of the

Hydro-Electric Power Commission of Ontario.

COPY

The area outlined in red shows the

Niagara System.



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

GENERAL MAP

SHOWING LOCATION OF
GENERATING STATIONS, TRANSFORMER STATIONS AND
TRANSMISSION LINES
Toronto, Feb. 10th, 1925. Made by [illegible] Checked by [illegible]
WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

INDEX TO NIAGARA SYSTEM
Part II

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

(Illus.)

LIST OF ILLUSTRATIONS

NIAGARA SYSTEM
Part II

(Illus.)

ENGINEERING

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Toronto, Ontario,

June 23rd, 1923.

Hydro-Electric Inquiry Commission,
W. D. Gregory, Esq., Chairman,
T O R O N T O, Ontario.

re Studies of Future Operations of the Generating Plants of the Hydro-Electric Power Commission of Ontario at Niagara Falls, and of the Niagara System of the Hydro-Electric Power Commission of Ontario.

Mr. Chairman and Gentlemen,-

To supplement the report dated June 15th, 1923, entitled "Study of Engineering Economics of the Niagara System of the Hydro-Electric Power Commission of Ontario", instructions have been given by your Commission, and conveyed through Mr. Bower, the Secretary, to make a study of the future operations of the generating plants at Niagara Falls in connection with the Niagara System of the Hydro-Electric Power Commission of Ontario. The work has been done under the direct personal supervision of Mr. Walter J. Francis, C.E., M.E.I.C., and of Mr. Frederick B. Brown, M.Sc., M.E.I.C., the members of the firm of Walter J. Francis & Company, in accordance with your instructions.

For information regarding the operations of the Niagara System up to October 31st, 1921, reference may be had to the above mentioned report dated June 15th, 1923.

The report included herewith as pages 1 to 32 inclusive refers in a general way to the period subsequent to October 31st, 1921, and is essentially

a study of the probable future operations in the district. The conclusions of the study, necessarily indefinite, should be read with the limitations of present information in mind.

The present comprehensive Niagara System is virtually new, and of a complex nature. Existing records while voluminous are of an evolutionary character, and cover but a relatively short working period. They are progressing with the operation of the newly constituted System, and therefore much of the information necessary for a positive analysis of the future situation is not now available in verified form. Definite figures as to costs and other details can be obtained only after several more years of comprehensive operation. The practical handling of the System in all its co-related parts is the only proof of its operating possibilities. In point of magnitude alone the Niagara System is without a precedent.

The operation of the Niagara System continues under the Operating Department of the Hydro-Electric Power Commission, the Chief Engineer, Mr. Gaby, receiving his reports directly from Mr. Don Carlos, head of the Operating Department. Mr. Gordon O. Philp, B.A.Sc., is in immediate charge of the operation and maintenance of the Queenston-Chippawa Power Development, The Ontario Power Company System, the Toronto Power Company Plant and Local Lines, having his staff so organized that the handling of all the Hydro-Electric Power Commission plants supplying the System is co-ordinated. This co-ordination has been a matter of evolution according as the larger elements of the System have been added from time to time recently.

General Description of the Niagara System.

The Niagara System of the Hydro-Electric Power Commission of Ontario now consists essentially of two departments, namely, the generating stations and the transmission and distributing system. The portion of the whole system designated in the working records of the Hydro-Electric Power Commission as the "Niagara System" consists only of the transmission and distribution lines with their accessories. Considered as an entity, however, in its broadest sense, the Niagara System may be said to include three large generating stations at Niagara Falls, nominally owned by the Hydro-Electric Power Commission of Ontario; one small generating plant at Erindale on the Credit River; a steam-driven reserve power plant in the City of Toronto; a potential supply of purchased power from the Canadian Niagara Power Company, at Niagara Falls; and a transmission system having about 475 miles of 110,000-volt steel transmission lines, and a secondary transmission and distribution system of over 1,000 miles of lower voltage lines, all lying in the district between Toronto and Windsor. In addition there is a large mileage of rural lines connected with the System.

The frontispiece shows the Niagara System in relation to the other Systems of the Hydro-Electric Power Commission, the area embraced by the Niagara System being outlined in red.

The details of the Niagara System are shown on the map included herewith as page 4.

For the sake of completeness a map of the transmission system of The Ontario Power Company is included herewith as page 5. A map giving all the

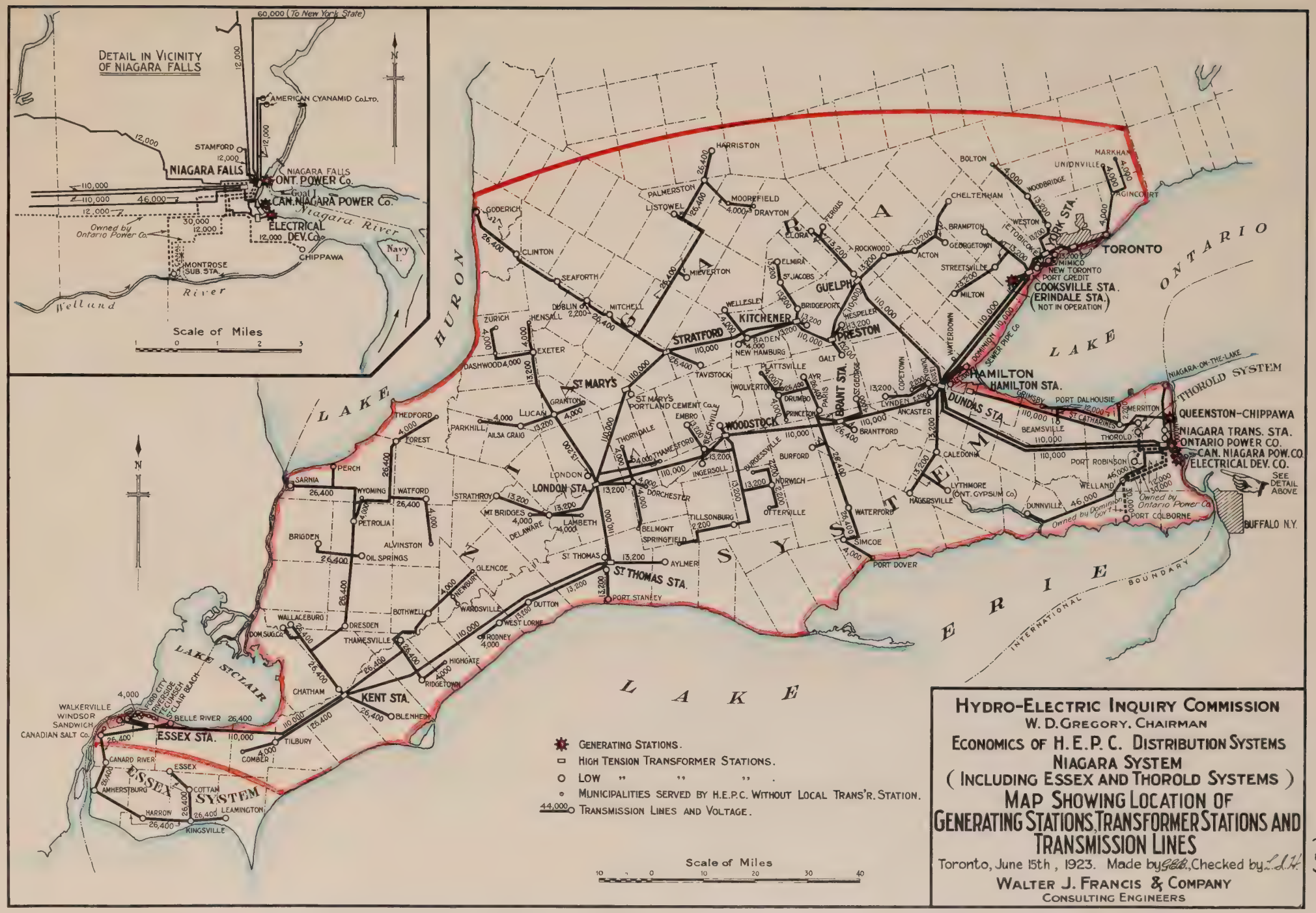
General Description of the Chippawa System.

The Chippawa System of the Hydro-Electric Power Commission of Ontario was initiated essentially by the Hydro-Electric Power Commission, however, the generating stations and the transmission and distributing systems. The portion of the whole system associated in the working problem of the Hydro-Electric Power Commission is the Chippawa Power Station, which is one of the hydro-electric plants in the Niagara Gorge, and the transmission lines with their substations. Originally in its entirety, however, in the broader sense, the Chippawa System may be said to include those large generating stations on the Niagara River, particularly those by the Hydro-Electric Power Commission, namely, the Queenston Station, the Decew Falls Station, and the Niagara Falls Station, and the transmission lines on the Niagara Peninsula, and the transmission system leaving Toronto, a potential supply of power from the Canadian Niagara Power Company, at Niagara Falls; and a transmission system leaving about 475 miles of 110,000-volt steel transmission lines, and a secondary transmission and distribution system of over 3,000 miles of lower voltage lines, all lying in the district between Toronto and Chippawa. In addition there is a large number of small lines connected with the system.

The circumstances under the Chippawa System in relation to the other systems of the Hydro-Electric Power Commission, the area embraced by the Niagara System being outlined in red.

The detail of the Chippawa System is shown on the map included herewith on page 4.

For the sake of description a map of the transmission system of the Ontario Power Company is included herewith on page 5. A map giving all the



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H.E.P.C. DISTRIBUTION SYSTEMS
NIAGARA SYSTEM
(INCLUDING ESSEX AND THOROLD SYSTEMS)

MAP SHOWING LOCATION OF GENERATING STATIONS, TRANSFORMER STATIONS AND TRANSMISSION LINES

Toronto, June 15th, 1923. Made by G.E.B., Checked by L.J.H.

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

(4)

- ✱ GENERATING STATION
- ▭ HIGH TENSION TRANSFORMER STATIONS
- ○ LOW TENSION " " OWNED BY O. P. Co.
- ◓ LOW TENSION " " OWNED BY CONSUMER
- ▰ HIGH TENSION " " OWNED BY ELECTRICAL DEV. Co.
- 12,000 ○ TRANSMISSION LINES AND VOLTAGE

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
THE ONTARIO POWER COMPANY OF NIAGARA FALLS
(INCLUDING THE ONTARIO TRANSMISSION Co., LIMITED)

MAP SHOWING LOCATION OF GENERATING STATION, TRANSFORMER STATIONS AND TRANSMISSION LINES

Toronto, May 14th., 1923. Made by G.E.B., Checked by L.D.H.

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

available data in regard to the System of the Toronto Power Company in included as page 7.

Conditions in 1922.

The year 1922 should be considered as a transition year for the Niagara System, because the Queenston-Chippawa Power Development commenced to deliver power in that year, although undergoing adjustment and extension in the early months of its operation, and because the circumstances of an accident to The Ontario Power Company in April, 1922, as elsewhere described in detail, set up effects which will be apparent until the later months of 1923, and also because in 1922 the Hydro-Electric Power Commission of Ontario took over the Toronto Power Company, including the plant of the Electrical Development Company at Niagara Falls. These were new factors particularly affecting the Niagara System.

The various operating figures and the costs for 1922, and possibly for 1923 and 1924, will therefore probably be quite different from those of the previous years, and the whole will probably have to operate for some time before a condition of stability will have been reached.

Future Market for Power.

From the year 1917 to the year 1921 inclusive, the demands for power in the Niagara district were so great that there was difficulty in adjusting the various loads so that all the customers could receive the power necessary for their operations. It is understood that modifications of many contracts were

available dues in ports in the Syrian or the Dutch East Indies, in Indonesia or Japan 2.

Conditions in 1941.

The year 1941 should be considered as a transition year for the Straits Ports, because the Japanese-Siamese Joint Development agreement in delivery power in that year, although subsequently altered and renegotiated in the early months of 1941 dramatic, and because the circumstances of an ambiguous to the future (year August in April, 1941, on standpoint Japanese in Malaya, and in attempts which will be expected negotiate peace months of 1941, and this because in 1941 the Siam-Malaya Joint Development of Malaya that over the Dutch East Company, including the years of the Commercial Development Company in Siamese ports. These were not Siamese particularly affecting the Straits ports.

The various operations Siamese and the ports for 1941, was greatly for 1941 was 1945, will therefore probably be quite extraordinary from those of the previous years, and the data will probably have to operate for some time before a condition of stability will have been reached.

Trade Losses for 1941.

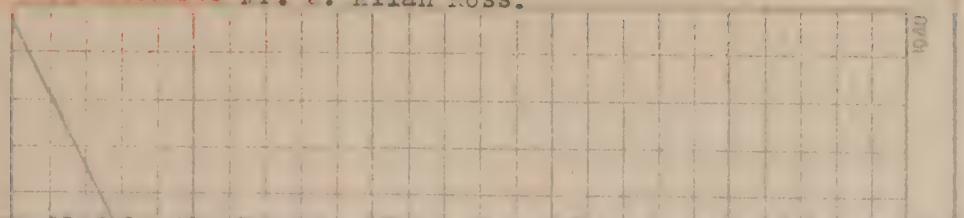
From the year 1937 to the year 1941 inclusive, the demands for power in the Siamese Malaya view so great that there was difficulty in maintaining the private lands so that all the machines could receive the power necessary for their operations. It is understood that modifications of many machines were


NOTE - THE INFORMATION PLOTTED ON THIS MAP INCLUDES ALL DATA AVAILABLE AT THIS DATE, JUNE 23RD., 1923. THE TRANSMISSION LINES INDICATED SHOW THE SERVICES FOR CUSTOMERS OTHER THAN ELECTRIC RAILWAYS.
KESWICK
NEWMARKET
AURORA
BOND LAKE
RICHMOND HILL
12,000
YORK MILLS
12,000
CAN. WIRE CABLE CO.
DURANT MOTOR
BLANTYRE
TERMINAL STA.
TOR. SUBURBAN
12,000
TORONTO
STEAM PLANT
HUMBER
GOODYEAR TIRE & RUBBER CO.
WHITBY
PORT UNION
PORT CREDIT
LAKE ONTARIO
International Boundary
N
90,000
OAKVILLE
BURLINGTON
HAMILTON
T. & N. P. Co.
TRANSMISSION SYSTEM
90,000
NIAGARA-ON-THE-LAKE
PT. DALHOUSIE
QUEENSTON
LEWISTON
ST. CATHARINES
Twentymile Creek
RIORDON PULP & PAP. Co
INTERLAKE TISSUE MILLS
N. ST. C. & T. RY.
ONT. PAPER CO.
NATIONAL ABRASIVES
12,000
THOROLD STA.
N. ST. C. & T. SUB STA.
EXOLON Co.
BEAVER-BOARD Co
NIAGARA FALLS
ELECTRICAL DEV. CO.
NIAG. FALLS STA.
60,000
90,000
12,000
CALEDONIA
CAN. ALOXITE Co
NORTON Co
Grand Island
60,000
Welland River
ELECTRO-METALS
12,000
WELLAND STA.
CAYUGA
Grand River
Scale of Miles
0 5 10 15
PT. MAITLAND
LAKE ERIE
GENERATING STATIONS
HIGH TENSION TRANSFORMER STATIONS
LOW TENSION TRANS. STATIONS (T.& N.P. Co.)
" " " " OWNED BY CONSUMER
TRANSMISSION LINES AND VOLTAGE
12,000
HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
NIAGARA SYSTEM
TORONTO POWER CO. AND SUBSIDIARIES
Toronto, June 23rd., 1923. Made by S.R.W., Checked by L.D.H.
WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

made to that end during the period. With the cessation of munition orders for war purposes it might have been expected that the power demands would have fallen off very largely. A study of the records shows that following the Armistice in November, 1918, there was for a short time a decrease in the loads in many places, but a remarkable increase soon developed, and it has been freely stated that until the third generating unit was installed and in operation at the Queenston-Chippawa plant, the Hydro-Electric Power Commission had great difficulty in keeping up with the load demands. At the present time, June, 1923, it is understood that the whole of the capacity of The Ontario Power Company, (about 175,000 H.P.), the whole of the capacity of the Electrical Development Company, (about 125,000 H.P.), the whole of the capacity of the Canadian Niagara Power Company, (about 100,000 H.P.), and the output of four machines in the Queenston-Chippawa plant is required to serve the various customers in Canada and in the United States receiving power from the plants on the Canadian side of the Niagara River. The indications are that the load will increase very rapidly, and that units Nos. 6, 7 and 8 now ordered for the Queenston-Chippawa plant will probably be fully loaded shortly after their installation.

For purposes of comparison it is interesting to note the growth of hydro-electric development in the Provinces of Ontario and Quebec from the year 1904 to 1922, together with the indications up to 1940. We have, therefore, plotted curves showing the date of installation of hydraulic turbines now in operation throughout the Provinces of Ontario and Quebec from 1904 to 1922, and have checked them by reference to the statistics of the Department of the Interior,

made so that was during the period. With the conversion of existing steam or oil plants it might have been argued that the power demands would have fallen off very largely. A study of the records shows that delivering the operation in December, 1918, there was for a short time a decrease in the loads in many places, but a remarkable increase soon followed, and in the time fully stated that until the entire generating plant, the Niagara-Cataract Power Commission has grown difficulty in keeping up with the load demands. In the present time, 1919, it is maintained that the whole of the capacity of the Ontario Power Company, (about 175,000 h.p.), the whole of the capacity of the Electrical Development Company, (about 120,000 h.p.), the whole of the capacity of the Canadian Niagara Power Company, (about 100,000 h.p.) and the majority

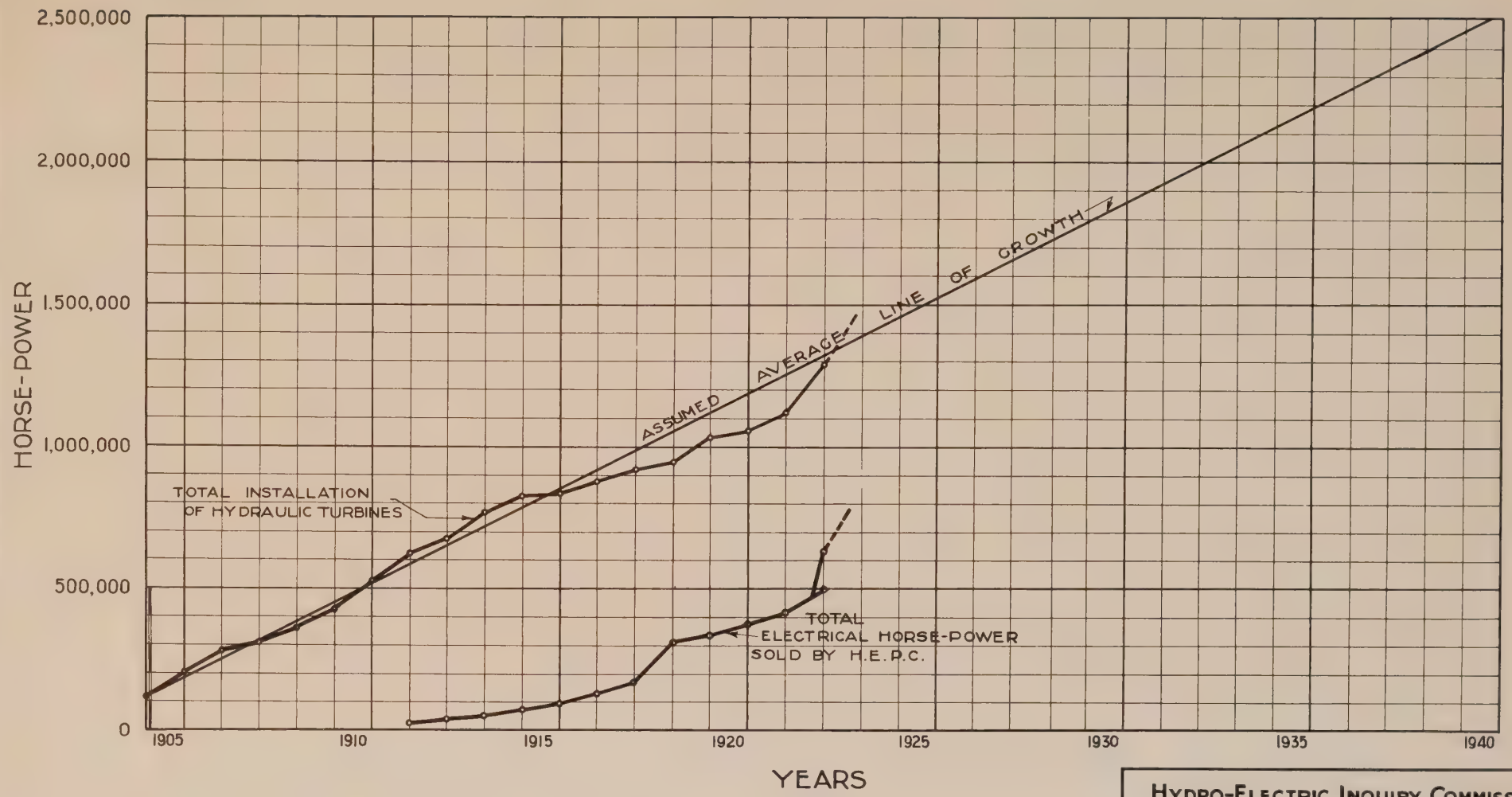


compiled by the Dominion Water Power Branch, of which Mr. J. B. Challies, C.E., M.E.I.C., is the Director. Plotted on the same sheet is an assumed average line of growth showing the probable installation at the year 1940 in each of the two provinces. These two curves are included herein as pages 10 and 11. On page 10 is plotted also the output of the Hydro-Electric Power Commission, approximately, for comparison with the total hydraulic installation in the Province of Ontario.

Page 12 shows the growth of all the Systems of the Hydro-Electric Power Commission. Incidentally, it shows what a great proportion of the whole the Niagara System constitutes.

As a further indication of the rate of growth of large generating stations and systems, we have obtained through the courtesy of the Shawinigan Water and Power Company, Montreal, a set of curves, included as page 13, showing the growth of the average load, the peak load and the generator capacity of the Company from its commencement up to date, with their estimate of the future growth to about the year 1931.

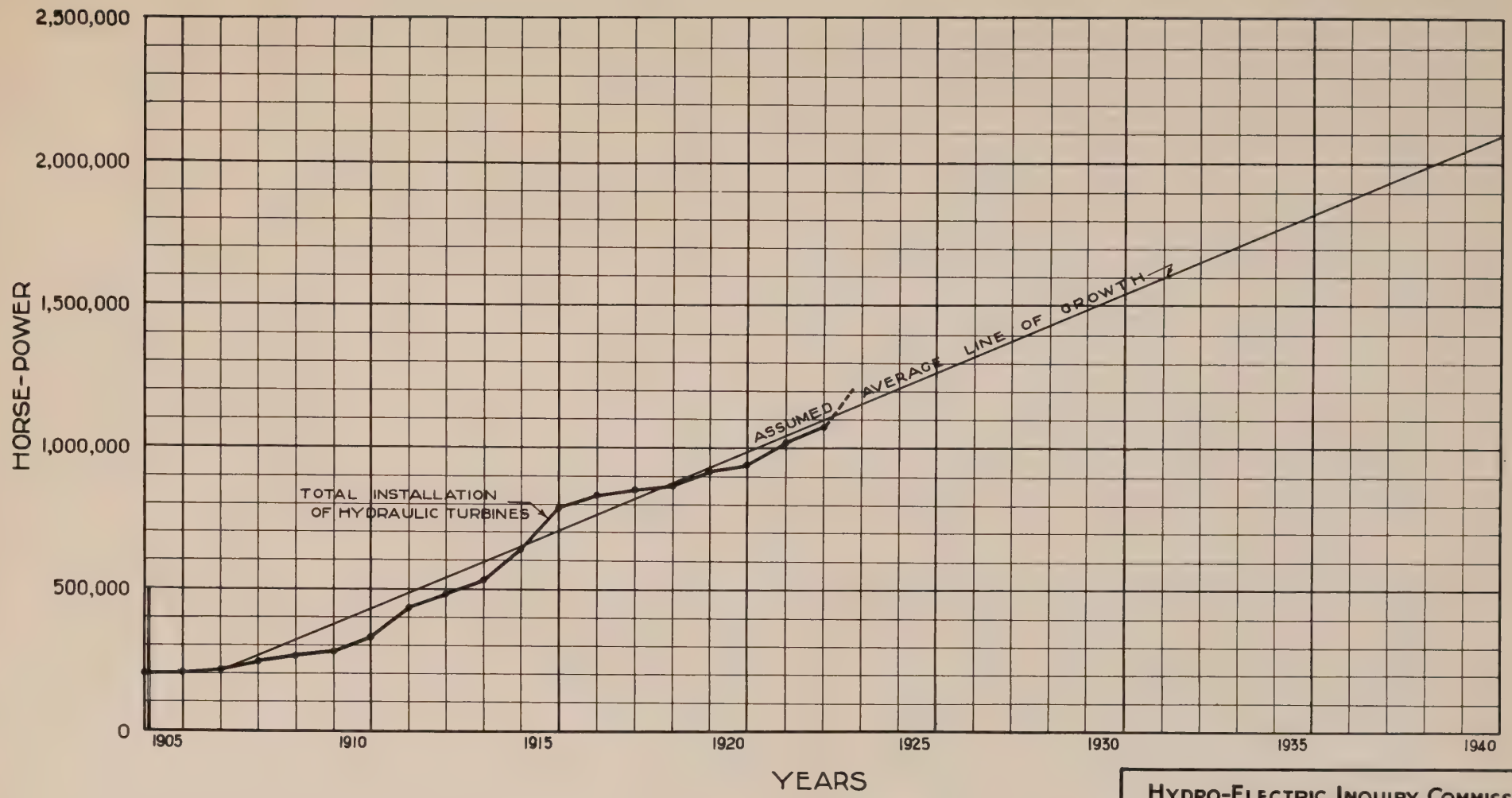
We have also studied similar records in the United States, and, as a result of these investigations, it would appear that on the whole a growth of about ten per cent. per annum may be expected in the Niagara District during the next decade or so, thus doubling the load every six or seven years. If this indication be confirmed, it will not be very long before the whole of the generating plants now completed or under construction on the Canadian side at Niagara Falls will be loaded to full capacity, and further sources of power supply must then be obtained if the industrial growth of the Province is to be



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

TOTAL HYDRAULIC INSTALLATION IN THE PROVINCE OF ONTARIO

Toronto, June 23rd, 1923. Made by [illegible], Checked by [illegible]
WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS



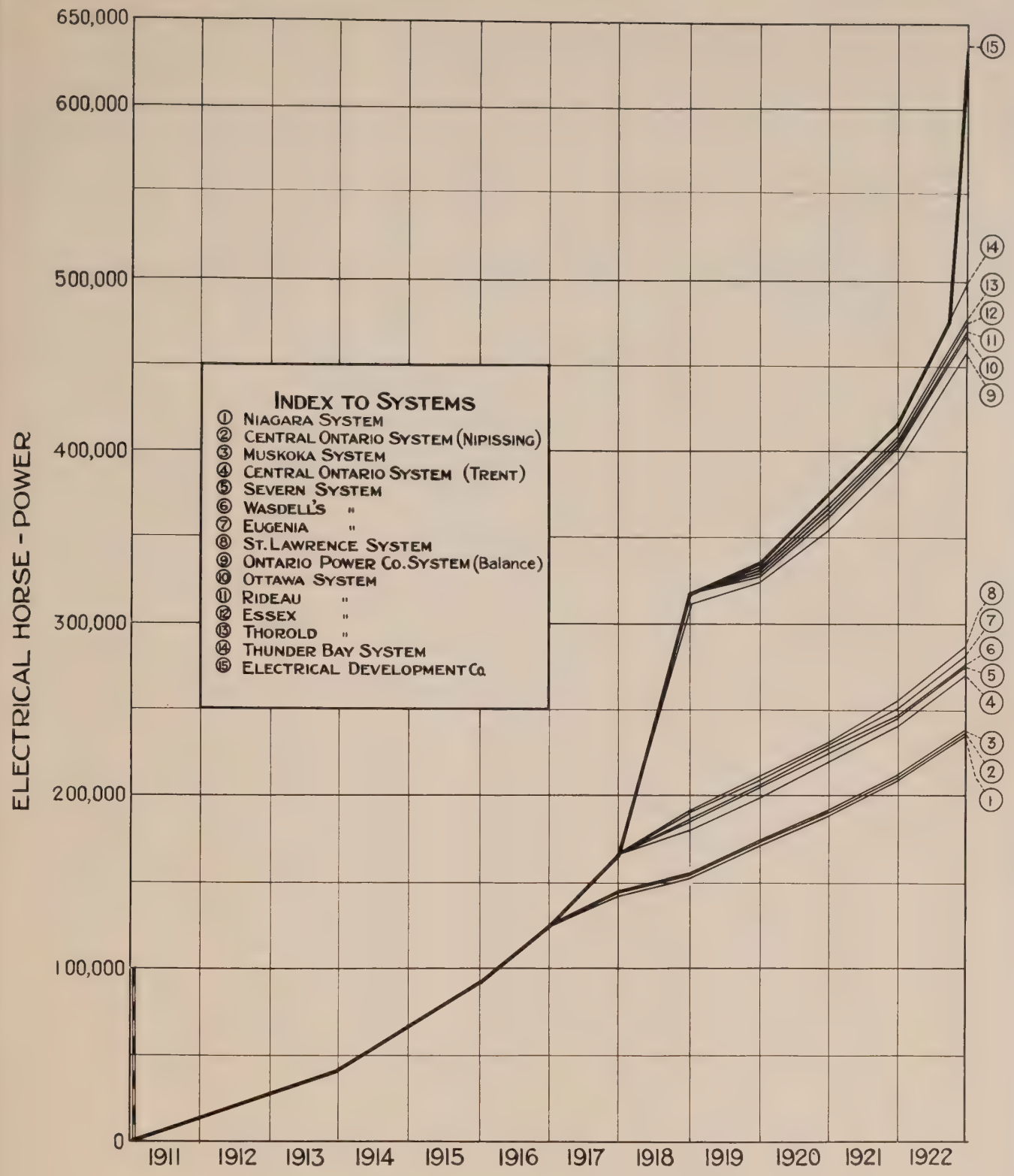
HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

TOTAL HYDRAULIC INSTALLATION IN THE PROVINCE OF QUEBEC

Toronto, June 23rd, 1923. Made by, Checked by

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

H. E. P. C. SYSTEMS

CURVES OF PEAK LOADS IN ELECTRICAL HORSE-POWER

Toronto, June 23rd, 1923. Made by GEO Checked by L. D. H

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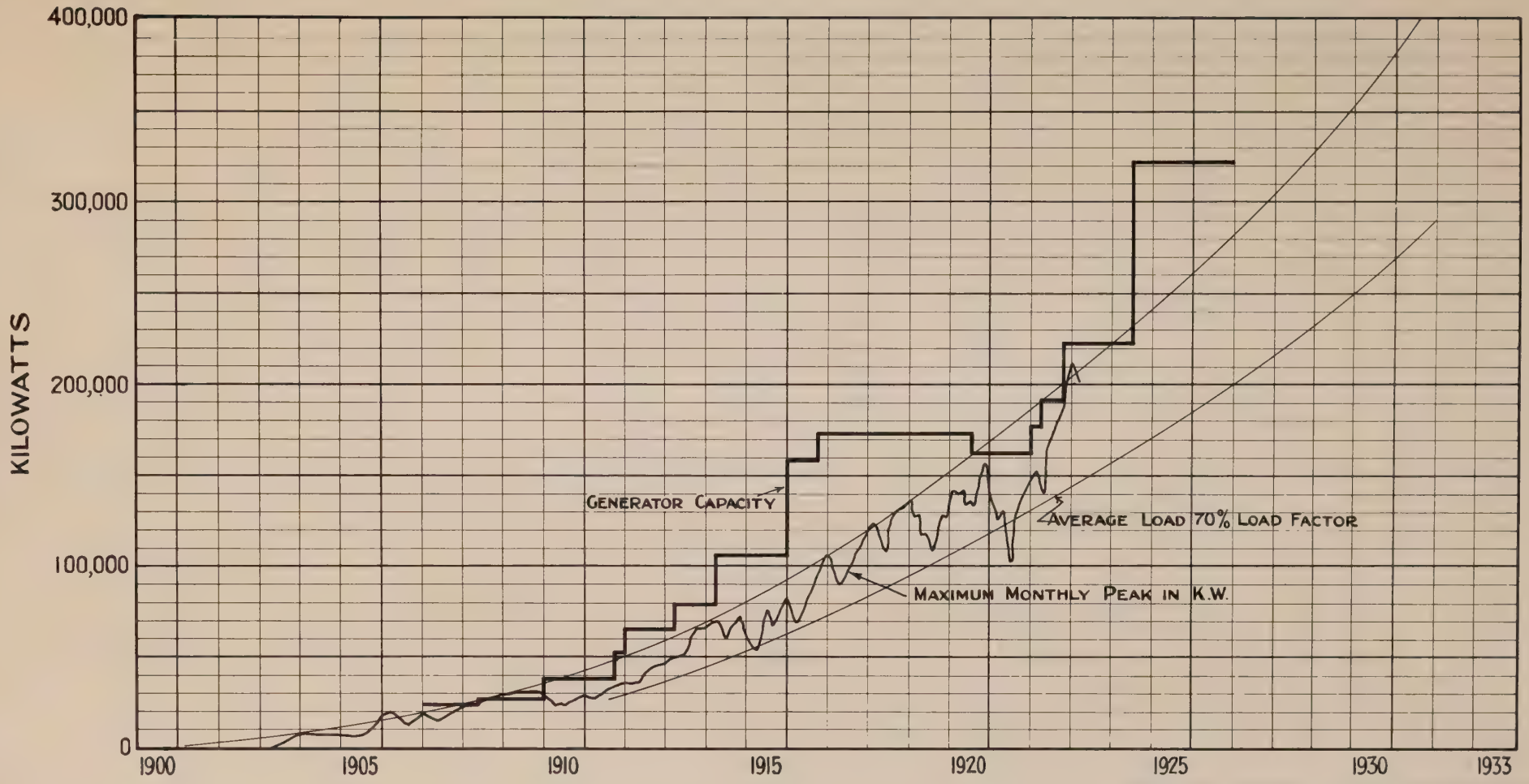
CONSULTING ENGINEERS



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

SHAWINIGAN WATER AND POWER CO.

LOAD CURVES

Toronto, June 23rd, 1923. Made by G.E.B., Checked by L.J.H.

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

maintained. It would therefore seem prudent to undertake studies of all feasible projects in the Niagara peninsula for still further increasing the available power supply and to have plans outlined for further developments before the time when the capacity of the Queenston-Chippawa plant will have been reached, probably within a comparatively few years.

Future Operations of Generating Plants at Niagara Falls.

The future operations of the various generating plants on the Canadian side at Niagara Falls will depend entirely on the amount of water diverted from the Niagara River and its method of application. The plants of the Canadian Niagara Power Company, the Electrical Development Company, The Ontario Power Company and the International Railway Company, all operate under heads which are considerably less than the difference in elevation of the water level in Lake Erie and that in Lake Ontario. The Queenston-Chippawa Power Development utilizes the full feasible head between Lake Erie and Lake Ontario. Many factors enter into the problem of utilizing the existing plants and future plants to best advantage. There is a large amount of capital invested in the first three older plants mentioned. All are in good condition. Built during times when capital costs were relatively low, the construction costs of the three plants represent an investment of a comparatively small sum per horse-power.

We have made studies as to the most advantageous operating use of the existing plants in combination during the next few years, and have prepared a table, included as page 15 hereof, showing the approximate quantities of power which each could deliver under what appear to be the best operating conditions,

maintained. It would therefore seem preferable to undertake studies of all possible projects in the Zambezi Valley with various transmission and distribution power supply and to have plans ready for further development when and when the capacity of the Cabora-Bassa plant will have been reached, probably within a comparatively few years.

Future developments of hydroelectric plants in Southern Africa.

The future developments of the various generating plants on the Zambezi side of Kariba Dam will depend entirely on the amount of water diverted from the Kariba Lake and the [illegible] of utilisation. The plants of the Umtali Falls Power Company, the Chicamba Development Company, the Mutirikwi Power Company and the Bangweulu Fishing Company, all operate under land which are invariably less than the difference in elevation of the main level in Kariba Lake and that in Lake Cabora-Bassa. The Cabora-Bassa Power Development utilises the full potential head between Lake Kariba and Lake Cabora. Many Rhodesian engineers have the problem of utilising the existing plants and Kariba plant to best advantage. There is a large amount of capital invested in the plant these plants represent. All are in good condition. Until further plant when capital costs were relatively low, the maintenance costs of the steam plants represent an investment of a comparatively small sum per kilowatt-hour.

In some cases studies of it the most advantageous operating use of the existing plants in conjunction having lot over the years, can show yearness a total, included as yet in hand, showing the alternative conditions of some which small factors which appear to be in the best operating conditions.

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

TABLE OF POWER OUTPUT

AT NIAGARA

Name of Plant	Probable Most Efficient Use	
	Horse-power	Water Required Cubic Feet per Second (limits)
		*a *b
Canadian Niagara Power Company	100,000	8,225 to 9,600 .....
Electrical Development Company	100,000	8,200 to 8,500 .....
International Railway Company	600 to 1,000	*f 125 to 200 .....
The Ontario Power Company	150,000	9,000 to 9,600 .....
Total	351,000 abt....	25,550 to 27,900 .....
Say, ...	350,000	27,000 .....

Details of some of the above given in public hearing, December 21st, 1922.

OF FOUR POWER PLANTS

FALLS, ONTARIO

	Present Ordinary Use		Possible Maximum Use	
	Horse-power	Water Required Cubic Feet per Second (limits)	Horse-power	Water Required Cubic Feet per Second (limits)
	100,000	*a 8,225 to *b 9,600	110,000	9,000 to 10,500
	125,000	*c 10,512 to *d 12,400	146,000	12,500 to *e 13,300
	1,500 to 2,000	300 to 400	4,000	800
	175,000	*g 11,180 to 12,000	193,000	*h 13,300 to 14,000
	402,000 abt.	31,217 to 34,400	453,000	35,600 to 38,600
	400,000	33,000	450,000	37,000

*a - Order-in-Council, June 18th, 1914, authorized 8,225 cubic feet per second with 76,750 H.P. then installed, but 100,000 H.P. probably contemplated.
*b - Estimates made by various authorities 1920.
*c - Order-in-Council, June 18th, 1914, authorized 9,985 cubic feet per second. Royal Commission, April 25th, 1916, gave 10,512 cubic feet per second.
*d - Estimate made in 1920 by United States authorities.
*e - Estimate made in summer of 1921, probably by officers of the Toronto Power Company.
*f - Estimate made by various authorities for about 550 to 600 H.P. load.
*g - Order-in-Council, June 18th, 1914, authorized 11,180 cubic feet per second with about 160,000 H.P. installed.
*h - Estimated by various authorities, and given in evidence by Mr.W.W.Pope, December 21st, 1922.

and under present normal use having regard to load factor and so forth, and under their possible maximum use. Included in the table are approximate figures for the quantity of water necessary for the operation of each plant under the three assumed conditions of use. It should be noted that the table is based on estimated quantities of water and on certain assumptions which are probably correct within the limits given. The actual quantities of water required for each plant under the different conditions outlined can be determined with accuracy only by means of a comprehensive system of tests, using either the Gibson or the Allen method according to circumstances. The authorities for the various quantities of water given in the table are stated in foot notes where available, and the remaining figures have been estimated by examining the records of the various plants so far as these have been made available.

Summing up the table it would appear that the most efficient use of the four older plants on the Canadian side would probably be at an output of about 350,000 horse-power, requiring approximately 27,000 cubic feet of water per second; that the present normal use of these four plants at about 400,000 horse-power requires approximately 33,000 cubic feet per second; and that the peak capacity of the four plants would give an output of about 450,000 horse-power, requiring about 37,000 cubic feet per second. The figures for peak capacity are in excess of what could be obtained continuously, and they represent really the peak capacity of the four plants individually.

It should be noted that in the table, being page 15 hereof, the Queenston-Chippawa Power Development is not included.

We have also prepared a table showing the possible output of the Queenston-

Chippawa Power Development with various amounts of water available under the assumed head at the plant, namely, about 305 feet, operating at an over-all efficiency of about 90 per cent. as has recently been demonstrated by tests. This table is shown below.

Power Available at Queenston-Chippawa Power Development,
305 Feet Head - 90 Per Cent. Efficiency

Flow, Cubic Feet per Second	Electrical H.P. Available	Flow, Cubic Feet per Second	Electrical H.P. Available
5,000	157,000	13,000	407,000
6,000	188,000	14,000	438,000
7,000	229,000	15,000	470,000
8,000	250,000	16,000	500,000
9,000	282,000	17,000	532,000
10,000	313,000	18,000	563,000
11,000	344,000	19,000	594,000
12,000	375,000	20,000	625,000

The table on page 15 shows the output of the four larger plants at Niagara Falls, Ontario, namely, that of the Canadian Niagara Company, the Electrical Development Company, The Ontario Power Company, and the International Railway Company. Briefly, the figures are as follows:

Water Used, Cubic Feet per Second	Output, Horse-power	Condition of Operation
27,000	350,000	Probable Most Efficient Use.
33,000	400,000	Ordinary Present Use.
37,000	450,000	Possible Maximum Use.

and it will be noted that 37,000 cubic feet of water per second is the probable peak amount required.

We have prepared figures to show the amount of power obtainable under the

three conditions set forth above by assumed volumes of water used by the four plants above enumerated working in conjunction with a plant having the principal characteristics of the Queenston-Chippawa plant, namely, a 305-foot head and 90 per cent. efficiency.

Taking first the condition of "Probable Most Efficient Use" the result is as follows:

Total Water Used Cubic Feet per Second	Four Plants in Combination: Water Used Cubic Feet per Second	Four Plants in Combination: Horse-power	305-Foot 90 Per Cent. Plant: Water Used Cubic Feet per Second	305-Foot 90 Per Cent. Plant: Horse-power
36,000	27,000	500,000	9,000	282,000
40,000	27,000	550,000	13,000	407,000
45,000	27,000	550,000	18,000	563,000
50,000	27,000	550,000	23,000	720,000
55,000	27,000	550,000	28,000	875,000

Similarly, for the condition of "Ordinary Present Use" the result is:

Total Water Used Cubic Feet per Second	Four Plants in Combination: Water Used Cubic Feet per Second	Four Plants in Combination: Horse-power	305-Foot 90 Per Cent. Plant: Water Used Cubic Feet per Second	305-Foot 90 Per Cent. Plant: Horse-power
36,000	33,000	400,000	3,000	94,000
40,000	33,000	400,000	7,000	229,000
45,000	33,000	400,000	12,000	375,000
50,000	33,000	400,000	17,000	532,000
55,000	33,000	400,000	22,000	688,000

In the same manner, for the condition of "Possible Maximum Use", we obtain the following:

Total Water Used Cubic Feet per Second	Four Plants in Combination Water Used Cubic Feet per Second	Horse-Power	305-Foot 90 Per Cent. Plant Water Used Cubic Feet per Second	Horse-power
36,000	37,000	450,000	-	-
40,000	37,000	450,000	3,000	94,000
45,000	37,000	450,000	8,000	250,000
50,000	37,000	450,000	13,000	407,000
55,000	37,000	450,000	18,000	563,000

Summing up the above information we obtain the following figures as representing the total output for the assumed flows tabulated, when used in the four Canadian plants now existing in combination with the Queenston-Chippawa plant or an extension thereof:

Total Water Used Cubic Feet per Second	At Probable Most Efficient Use	At Ordinary Present Use	At Possible Maximum Use
36,000	632,000	494,000	438,000
40,000	757,000	629,000	544,000
45,000	913,000	775,000	700,000
50,000	1,070,000	932,000	857,000
55,000	1,225,000	1,088,000	1,013,000

From these figures it will be seen that with a total diversion on the Canadian side of the Niagara River amounting to 45,000 cubic feet per second, the four plants on the Canadian side, namely, the Canadian Niagara, the Electrical Development, The Ontario Power and the International Railway, could deliver about 350,000 horse-power and leave enough water to generate efficiently

In the same summary, for the municipal of Tonkatin Southern Ont., we obtain the following:

Total Water Used during first year	Water Used during Peak Hour	Capacity of Pumps	Capacity of Pumps Used during Peak Hour
31,000	37,000	450,000	[illegible]
33,000	37,000	450,000	[illegible]
35,000	37,000	450,000	[illegible]
37,000	37,000	450,000	[illegible]
39,000	37,000	450,000	[illegible]

Dealing in the above information we obtain the following figures at re-presenting the total capacity of the pumps, which is the water used in the Tonkatin plants now pumping in conjunction with the Tonkatin-Ontario plant or an extension thereof:

Total Water Used during first year	As Compared Then Actually Use	As Compared Pumps Used	As Compared Pumps Used
31,000	[illegible]	[illegible]	[illegible]
33,000	[illegible]	[illegible]	[illegible]
35,000	[illegible]	[illegible]	[illegible]
37,000	[illegible]	[illegible]	[illegible]
39,000	[illegible]	[illegible]	[illegible]

From these figures it will be seen that with a total diversion in the Tonkatin plant of the Thames River amounting to 15,000 gallons per minute, the two plants on the Ontario side, namely, the Tonkatin Pumps, the Ontario Pumps Development, the Ontario River and the Intermediate Intake, make unless about 600,000 Imp.-gpm and have enough water to provide sufficient

about 563,000 horse-power at the Queenston-Chippawa plant, or a total from all five plants of about 913,000 horse-power. The apparent anomaly of the amounts under the heading "Possible Maximum Use" being less than those under the caption "Ordinary Present Use", arises primarily from the difficulty of devising comprehensively descriptive terms to apply to the many combinations of conditions. The last table indicates the advisability of operating the Queenston-Chippawa plant to its maximum, leaving the less efficient plants to use the balance of the available water. At the same time the table serves to emphasize the statement made in the early part of this report that the practical handling of the co-related plants is the only proof of the maximum capacity and efficiency of the group for any stated quantity of water.

The Future Operations of the Hydro-Electric Power Commission Plants at Niagara Falls.

The plants now nominally owned and controlled by the Hydro-Electric Power Commission of Ontario at Niagara Falls are The Ontario Power Company, the Electrical Development Company, and the Queenston-Chippawa plants. The Commission also owns a steam plant in Toronto which was purchased with the other properties of the Toronto Power Company, in what is known as the "Clean-up Deal".

We have endeavoured to obtain figures showing the costs and segregated values of the various properties entering into the purchase of the Toronto Power Company assets, but we have been advised by the officials of the

about 240,000 horse-power at the Jacquesche-Ottawa plant, or a total area of the plants of about 414,000 horse-power. The original capacity of the original units for treating "Canadian Western Ore" below had that which under the original "Ottawa Process Ore", which was practically zero. Difficulty is initially encountered by manufacturers there in spite of the same particular nature of measurement. The last mills illustrate the advisability of operating the "Jacquesche-Ottawa" plant on the measure, having for have efficient plants by the use because of the analysis under, as the same time the trial forces of separating the chemicals made in the early part of this report that the practical working of the co-related plants in the main plant of the Jacquesche-Ottawa was efficient of the terms for the alloyed [illegible].

The Ottawa Operations of the Ontario-Electric Power Development Commission of Ontario.

The plants are practically owned and controlled by the Ontario-Electric Power Commission of Ontario at Ottawa Falls are the Ontario Power Company, the Electrical Development Company, and the Jacquesche-Ottawa Plants. The Ontario plants also form a close alloy in numerous ways physically with the other properties of the Canada Power Company, in what is known as the "Ottawa-Up Dam".

In many relationship in which Electric working the main are interrelated with of the Ottawa properties working into the purpose of the "Canada Power Company" which is here based mainly by the activities of the

Hydro-Electric Power Commission that nothing is yet available which may be considered accurate enough for basing an analysis upon. We are, therefore, not in a position to give any figures at the present time with regard to the segregated costs or valuations of the various portions of this property. We have, however, obtained through the engineers of the Hydro-Electric Power Commission a set of estimates showing the various operating costs and fixed charges for The Ontario Power Company, the Toronto steam plant, the Electrical Development Company plant, the Queenston-Chippawa Power Development plant, with five, with six, with seven, with eight, with nine and with ten units, and a combination of all four plants. In these estimates the capital value of the Toronto steam plant is given as $1,500,000, and the Electrical Development plant as $13,000,000.

The estimates are given in tabular form and are inserted as pages 22 to 26 hereof, inclusive, and show the present estimates of the Hydro-Electric Power Commission with regard to the cost of power at Niagara Falls.

On pages 27, 28 and 29, immediately following the tables, explanatory notes are given in an amplified form of the brief notes written on the original tables, the amplification having been made as a result of conferences of our Mr. Brown with Mr. A. H. McBride, the officer in charge of the estimating work in the head office of the Hydro-Electric Power Commission, and with other officers of the Hydro-Electric Power Commission. The notes regarding water rentals are given at the foot of each table. The estimated average cost of power per horse-power per annum at the 12,000-volt bus bars at Niagara Falls, according to the several assumptions of power output in the tables, ranges between $14.59 and $12.47, as will be seen by reference thereto.

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

Hydro-Electric Power Commission Estimate.

ESTIMATE FOR

ESTIMATE OF OPERATING EXPENSES OF THE ONTARIO POWER COMPANY, THE TORONTO

INCLUDING TORONTO STEAM

	Ontario Power Company Plant 150,000 Horse-power	Toronto Steam Plant (Not Operating)
Capital	$25,547,458	$1,500,000
No. 16 Unit	50,000	
Annual Charges		
Interest	1,138,718	75,000, (5%)
Bank Exchange, Bond Discounts, and so forth	72,846	-
Operation and Indirect Charges	158,225	-
Maintenance	112,897	-
Taxes and Insurance	94,390	27,517
Sinking Fund	297,272	15,000, (1%)
Depreciation (Omit Third Pipe Line)	45,921	-
Water Rental	102,500	-
Add Charges on No. 16 Unit, O.P.Co. Interest, 6%; Sinking Fund, 1.6%; Depreciation, 0.38%	4,090	-
Total	$2,026,859	$117,517

COPY

Note re Water Rentals.

	The Ontario Power Company	Toronto Power Company	Queenston-Chippawa Power Development
First 40,000 H.P.	$ 47,500		Estimated at 30¢ per Horse-power throughout
Second 30,000 H.P.		$52,500	
Balance at 50¢	55,000	35,000	
Yearly total	$102,500	$67,500	

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross. February 21st, 1923. (22)

550,000 H.P.

POWER COMPANY, AND THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT,

PLANT (NOT OPERATING)

Electrical Development Plant 100,000 Horse-power	Queenston-Chippawa Power Development Five Units 300,000 Horse-power	Total of Four Plants Three Operating 550,000 Horse-power
$13,000,000	$64,370,180	$104,417,633
		50,000
650,000, (5%)	3,862,211, (6%)	5,725,929
5,880	-	78,726
152,868	153,500	464,593
76,373	103,000	292,270
52,429	10,000	184,336
130,000, (1%)	Deferred	442,272
87,500	80,810	214,251
67,500	82,500	252,500
-	-	4,090
$1,222,550	$4,292,021	$7,658,947

COPY

Average cost per horse-power per annum at 12,000-volt bus bars
at Niagara Falls at 550,000 H.P. rating = $13.93.
at 525,000 H.P. rating = $14.59.

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

Hydro-Electric Power Commission Estimate.

ESTIMATE FOR

ESTIMATE OF OPERATING EXPENSES OF THE ONTARIO POWER COMPANY, THE TORONTO

INCLUDING TORONTO STEAM

	Ontario Power Company Plant 150,000 Horse-power	Toronto Steam Plant (Not Operating)
Capital	$25,547,453	$1,500,000
No. 16 Unit	50,000	
Annual Charges		
Interest	1,138,718	75,000, (5%)
Bank Exchange, Bond Discounts, and so forth	72,846	-
Operation and Indirect Charges	158,225	-
Maintenance	114,897	-
Taxes and Insurance	94,390	27,517
Sinking Fund	297,272	15,000, (1%)
Depreciation (Omit Third Pipe Line)	45,921	-
Water Rental	102,500	-
Add Charges on No. 16 Unit, O.P.Co. Interest, 6%; Sinking Fund, 1.8%; Depreciation, 0.38%	4,090	-
Total	$2,026,859	$117,517

COPY

Note re Water Rentals:

	The Ontario Power Company	Toronto Power Company	Queenston-Chippawa Power Development
First 40,000 H.P.	$ 47,500		Estimated at 30¢ per Horse-power throughout
Second 30,000 H.P.		$32,500	
Balance at 50¢	55,000	35,000	
Yearly total	$102,500	$67,500	

February 21st, 1923.

600,000 H.P.

POWER COMPANY, AND THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT,

PLANT (NOT OPERATING)

	Electrical Development Plant 100,000 Horse-power	Queenston-Chippawa Power Development Six Units 350,000 Horse-power	Total of Four Plants Three Operating 600,000 Horse-power
..	$13,000,000	$67,149,651	$107,197,104
.....			50,000
..	650,000, (5%)	4,028,979	5,892,697
..	5,880	-	78,726
..	152,868	166,475	477,568
..	76,373	115,000	304,270
.	52,429	10,000	184,336
.	130,000, (1%)	Deferred	442,272
.	87,500	92,503	225,924
.	67,500	105,000	275,000
.	-	-	4,090
.	$1,222,550	$4,517,957	$7,884,885

Average cost per horse-power per annum at 12,000-volt bus bars at Niagara Falls at 600,000 H.P. rating = $13.14.

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

Hydro-Electric Power Commission Estimate.

ESTIMATE FOR

ESTIMATE OF OPERATING EXPENSES OF THE ONTARIO POWER COMPANY, THE TORONTO

INCLUDING TORONTO STEAM

	Ontario Power Company Plant 150,000 Horse-power	Toronto Steam Plant (Not Operating)
Capital	$25,547,453	$1,500,000
No. 16 Unit	50,000	
Annual Charges		
Interest	1,138,718	75,000, (5%)
Bank Exchange, Bond Discounts, and so forth	72,845	-
Operation and Indirect Charges	158,225	-
Maintenance	112,897	-
Taxes and Insurance	94,390	27,517
Sinking Fund	297,272	15,000, (1%)
Depreciation (Omit Third Pipe Line)	45,921	-
Water Rental	102,500	-
Add Charges on No. 16 Unit, O.P.Co. Interest, 6%; Sinking Fund, 1.8%; Depreciation, 0.38%	4,090	-
Total	$2,026,859	$117,517

COPY

Note re Water Rentals:

	The Ontario Power Company	Toronto Power Company	Queenston-Chippawa Power Development
First 40,000 H.P.	$ 47,500		Estimated at 30¢ per Horse-power throughout
Second 30,000 H.P.		$32,500	
Balance at 50¢	55,000	35,000	
Yearly total	$102,500	$67,500	

February 21st, 1923.

650,000 H.P.

POWER COMPANY, AND THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT,

PLANT (NOT OPERATING)

Electrical Development Plant 100,000 Horse-power	Queenston-Chippawa Power Development Seven Units 400,000 Horse-power	Total of Four Plants Three Operating 650,000 Horse-power
$13,000,000	$69,940,392	$109,987,845
		50,000
650,000, (5%)	4,196,423	6,060,141
5,880	-	78,726
152,868	179,450	490,543
76,373	127,000	316,270
52,429	10,000	184,336
130,000, (1%)	Deferred	442,272
87,500	103,862	237,283
67,500	120,000	290,000
-	-	4,090
$1,222,550	$4,736,735	$8,103,661

Average cost per horse-power per annum at 12,000-volt bus bars at Niagara Falls at 650,000 H.P. rating - $12.47.

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

Hydro-Electric Power Commission Estimate.

ESTIMATE FOR

ESTIMATE OF OPERATING EXPENSES OF THE ONTARIO POWER COMPANY, THE TORONTO

INCLUDING TORONTO STEAM

	Ontario Power Company Plant 150,000 Horse-power	Toronto Steam Plant (Not Operating)
Capital	$25,547,453	$1,500,000
No. 16 Unit	50,000	
Annual Charges		
Interest	1,138,718	75,000, (5%)
Bank Exchange, Bond Discounts, and so forth	72,846	-
Operation and Indirect Charges	158,225	-
Maintenance	112,897	-
Taxes and Insurance	94,390	27,517
Sinking Fund	297,272	15,000, (1%)
Depreciation (Omit Third Pipe Line)	45,921	-
Water Rental	102,500	-
Add Charges on No. 16 Unit, O.P.Co. Interest, 6%; Sinking Fund, 1.8%; Depreciation, 0.36%	4,090	-
Total	$2,026,859	$117,517

COPY

Note re Water Rentals:

	The Ontario Power Company	Toronto Power Company	Queenston-Chippawa Power Development
First 40,000 H.P.	$ 47,500		Estimated at 30¢ per Horse-power throughout
Second 30,000 H.P.		$32,500	
Balance at 50¢	55,000	35,000	
Yearly total	$102,500	$67,500	

WALTER J. FRANCIS & COMPANY.

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February 21st, 1923.

700,000 H.P.

POWER COMPANY, AND THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT,

PLANT (NOT OPERATING)

Electrical Development Plant 100,000 Horse-power	Queenston-Chippawa Power Development Eight and Nine Units 450,000 Horse-power	Total of Four Plants Three Operating 700,000 Horse-power
$13,000,000	$75,831,067	$115,878,520
		50,000
650,000, (5%)	4,549,864	6,413,582
5,880	-	78,726
152,868	201,625	512,718
76,375	146,000	335,270
52,429	10,000	184,336
130,000, (1%)	758,310, (1%)	1,200,582
87,500	126,765	260,186
67,500	135,000	305,000
-	-	4,090
$1,222,550	$5,927,564	$9,294,490

Average cost per horse-power per annum at 12,000-volt bus bars at Niagara Falls at 700,000 H.P. rating - $13.28.

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

Hydro-Electric Power Commission Estimate.

ESTIMATE FOR

ESTIMATE OF OPERATING EXPENSES OF THE ONTARIO POWER COMPANY, THE TORONTO

INCLUDING TORONTO STEAM

	Ontario Power Company Plant 150,000 Horse-power	Toronto Steam Plant (Not Operating)
Capital	$25,547,453	$1,500,000
No. 16 Unit	50,000	
Annual Charges		
Interest	1,128,718	75,000, (5%)
Bank Exchange, Bond Discounts, and so forth	72,846	-
Operation and Indirect Charges	158,225	-
Maintenance	112,897	-
Taxes and Insurance	94,390	27,517
Sinking Fund	297,272	15,000, (1%)
Depreciation (Omit Third Pipe Line)	45,921	-
Water Rental	102,500	-
Add Charges on No. 16 Unit, O.P.Co. Interest, 6%; Sinking Fund, 1.8%; Depreciation, 0.38%	4,090	-
Total	$2,026,859	$117,517

Note re Water Rentals:

	The Ontario Power Company	Toronto Power Company	Queenston-Chippawa Power Development
First 40,000 H.P.	$ 47,500		Estimated at 30¢ per Horse-power throughout
Second 30,000 H.P.		$32,500	
Balance at 50¢	55,000	35,000	
Yearly total	$102,500	$67,500	

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

February 21st, 1923.

750,000 H.P.

POWER COMPANY, AND THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT,

PLANT (NOT OPERATING)

Electrical Development Plant 100,000 Horse-power	Queenston-Chippawa Power Development Ten Units 500,000 Horse-power	Total of Four Plants Three Operating 750,000 Horse-power
$13,000,000	$82,483,914	$122,531,367
		50,000
650,000, (5%)	4,949,034	6,812,752
5,880	-	78,726
152,868	211,500	522,593
76,373	153,000	342,270
52,429	10,000	184,336
130,000, (1%)	824,484	1,266,756
87,500	142,793	276,214
67,500	150,000	320,000
-	-	4,090
$1,222,550	$6,440,811	$9,807,737

Average cost per horse-power per annum at 12,000-volt bus bars at Niagara Falls at 750,000 H.P. rating = $13.07.

Notes Relating to the Tables.

The following notes relate to the tables of estimates for 550,000 horse-power, 600,000 horse-power, 650,000 horse-power, 700,000 horse-power, 750,000 horse-power, combined output at Niagara Falls, pages 22, 23, 24, 25 and 26.

The load given for each of the four plants in the five tables is the estimated output for combined operation. With five units in the Queenston-Chippawa Power Development, 300,000 horse-power is an overload rating of that plant, the nominal rating being about 275,000 horse-power for the five units. With six units the nominal rating is 330,000 horse-power, while the estimated output for six units is 35[illegible],000 horse-power. Similarly, for seven units the nominal rating is 385,000 horse-power, and the estimated output is 400,000 horse-power. With eight units installed the nominal rating is 440,000 horse-power, and with nine units is 495,000 horse-power. The estimated output is the same for eight or for nine units, and with nine units a little spare capacity is available. With ten units the nominal rating is 550,000 horse-power, but one machine is considered as a spare, the estimated output being 500,000 horse-power,

The capital cost figures for The Ontario Power Company are made up of about $12,036,000 for tangible values in the plant itself as in 1917, about $3,511,000 for the "Third Pipe Line Extension", and about $10,000,000 allowed for intangibles.

The capital costs of the Toronto steam plant and of the Electrical Development plant are approximations.

The Queenston-Chippawa capital costs are from the records of the Hydro-Electric Power Commission.

Capital costs for transformation, transmission, and distribution are not included for any of the plants.

The item of $50,000 for No. 16 unit is a preliminary estimate of the cash expenditure required to instal a reconstituted unit in The Ontario Power Company plant, following the accident on April 20th, 1922.

The interest figures for The Ontario Power Company are taken at the actual rates payable on the various issues of securities.

Interest on the Electrical Development plant and on the Toronto steam plant is estimated at 5 per cent., being the average interest rate on the "Clean-up Deal".

Interest on the Queenston-Chippawa Power Development is estimated at an average of 6 per cent.

Indirect charges are estimated throughout at 35 per cent. of Operation and Maintenance.

Taxes and Insurance are taken at actual rates. Taxes appear only for The Ontario Power Company, the Toronto steam plant, and the Electrical Development plant. No taxes are included for the Queenston-Chippawa Power Development.

Sinking fund for The Ontario Power Company is taken at the rates required, while for the Toronto steam plant, and for the Electrical Development plant, it

is assumed at 1 per cent.

Sinking fund on the Queenston-Chippawa Power Development is assumed to be deferred until the eighth and ninth units are installed.

Depreciation (or reserve for renewals fund) is based on recently revised rates and the averages are as follows: The Ontario Power Company, sinking fund basis, 0.38 per cent. on tangible capital; Toronto Power Company, straight line basis, 1.25 per cent.; Queenston-Chippawa Power Development, sinking fund basis, 0.126 per cent. for five units, 0.138 per cent. for six units, 0.149 per cent. for seven units, 0.167 per cent. for eight and for nine units, and 0.173 per cent. for ten units.

Depreciation has not been allowed or included on the Third Pipe Line Extension of The Ontario Power Company, nor on the Toronto steam plant.

The whole of the annual charges on The Ontario Power Company are based on the preliminary 1923 estimated operating statement of the accounting department, but water rentals, indirect charges and depreciation are changed from this to suit later information.

The whole of the annual charges on the Toronto Power Company plants is based on estimated operating statements prepared for the accounting department by former employees of the Toronto Power Company now in the employ of the accounting department.

The operating and maintenance charges for the Queenston-Chippawa Power Development are based on the estimates of the operating department.

A study of the records given in the reports to your Commission on the engineering economics of The Ontario Power Company, under date of June 7th, 1923, and of the Niagara System under date of June 15th, 1923, will show the costs of power to October 31st, 1922, for The Ontario Power Company; and to October 31st, 1921, for the Niagara System. It should be noted that these costs include all the distribution costs as well as the costs at Niagara Falls.

In order to estimate the cost of power at points of delivery on the Niagara System under future conditions of operation, it would be necessary to have available accurate figures on the cost of generation after the various units will have been installed at the Queenston-Chippawa plant, and in addition the costs of installation of the extensions to the step-up transformer stations, transmission lines, and step-down transformer stations and distributing stations throughout the System. As this is entirely in the future, figures which might be given could only be regarded as approximate estimates, but a study of the figures in the reports already presented, in conjunction with this report, will indicate the limits of the cost of the power.

Summary.

A summary of a number of the more salient points which have been studied and discussed in the foregoing report, as well as in that of June 15th, 1923, may be of advantage in concluding the consideration of the economics of the Niagara System. They are as follows:

(1) The capital costs of the Niagara System proper, i.e., the distributing system only, contain nothing for intangible values. It

would, however, seem proper to include in the Niagara System the transformer and distributing stations and also the transmission lines of The Ontario Power Company, of the Toronto Power Company, and of the Queenston-Chippawa Power Development, because these are all delivering power in the Niagara System territory. In this case there would be included in the capital costs an item for intangibles representing a part of the intangible costs of the two first-mentioned plants.

In its more limited sense the capital costs of the System "per horse-power purchased" are of the order of $90.00, about one-half of this amount representing the cost of transmission lines, and the remainder the cost of transformer and distributing stations.

(2) Considering the Niagara System in its broadest sense, including the three generating stations, The Ontario Power Company, the Toronto Power Company, and the Queenston-Chippawa Power Development, the total capital cost and capacity as at October 31st, 1922, may be taken approximately as shown below, the costs being for electrical power at high voltage:

Company	Approximate Capital Cost	Approximate Capacity Horse-power
Ontario Power Company	$ 30,000,000	175,000
Toronto Power Company	25,000,000	125,000
Queenston-Chippawa Development ..	65,000,000	300,000
Niagara System Lines and Transformer Stations	20,000,000	50,000 *
Total	$140,000,000	650,000 H. P.

* This amount purchased from Canadian Niagara Power Company.

$$\text{Capital Cost per horse-power developed plus purchased} = \frac{\$140,000,000}{650,000} = \$215.00$$

Subsequent to October 31st, 1922, the contract with the Canadian Niagara Power Company has been reduced from 50,000 to 20,000 horse-power, making the capital cost per horse-power developed plus purchased $225.80 instead of $215.00.

The operation of the above plants at a total combined output of 650,000 horse-power would require a diversion of approximately 11,700 cubic feet of water per second for The Ontario Power Company, 12,400 for the Toronto Power Company, 10,000 for the Queenston-Chippawa Power Development, 4,500 for the Canadian Niagara Power Company (about one-half of its capacity), making a total of about 38,600 cubic feet of water per second.

(3) The average wholesale cost of power purchased for the Niagara System was $9.00 per horse-power per annum in the period from 1912 to 1915; $9.48 in 1916; $10.11 in 1917; $10.06 in 1918; $10.25 in 1919; $11.36 in 1920; $12.55 in 1921; and $16.55 in 1922.

Whether it has reached a maximum or not depends largely on the future agreements between the Hydro-Electric Power Commission and the generating plants and on future agreements regarding the diversion of water from the Niagara River. If an amount of water is available on the Canadian side sufficient to supply the full requirements of The Ontario Power Company, of the Toronto Power Company, and for the maximum requirements of the Queenston-Chippawa Power Development estimated at about 550,000 or 600,000 horse-power, it will be possible for the Commission to develop a total of about 900,000 horse-power at a capital cost of approximately $165,000,000, or $184.00 per horse-power. This would probably result in a considerable reduction in power cost below the 1922 figures.

(4) To facilitate future economic studies, as well as to assist in operating efficiency, it would be well to consider keeping accurate records of kilowatt-hours used at each principal consuming point on the System, for instance, at each of the distributing stations as well as at the main receiving stations on the System, and at the receiving station of each of the private companies taking power from the generating stations owned and operated by the Commission.

(5) The market for power has been well covered in the district, but it does not seem as yet to have reached the saturation point. The demand is apparently increasing at a rate of about 10 per cent. per annum, which, if continued, will double the output in seven years of thereabouts.

(6) The reserve for renewals should be carefully considered in its relation to the recently revised estimated useful life for various portions of the property, and should also be adjusted to allow for the actual cost of money year by year.

(7) The reserve for contingencies might with advantage be studied with a view to building up a larger amount to provide against contingencies, accidents, and so forth.

(8) The broad question of taxes, raised in the explanation of the tables of power cost, might be further considered in its relation to the cost of power. At present some of the plants are being charged with taxes, while other portions of the properties are not so charged. It would seem reasonable to have all the properties on the same basis if possible.

The general principle of taxation of the properties as a source of ordinary municipal revenue might well be considered in this connection.

Walter J. Francis
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Toronto, June 23rd, 1923.